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SECOND ALTERNATIVE ENERGY STORAGE

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Grade: A -

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Final Year Project Report ☑

Masters ☐

PhD ☐

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SECOND ALTERNATIVE ENERGY STORAGE

GIBSON CONELLY PHANG

A final year project report submitted in partial fulfilment of
the requirement for the degree of
Bachelor of Engineering (Hons) In Electronics (Computer)

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To my beloved family and friends.

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I would like to express my heartfelt gratitude to God for the good health and positive vibes that have given me this valuable opportunity to have my final year of study. It is a successful one that I have accomplished my previous semesters for 3 years. Everything done very well during my study in UNIMAS and I am very fortunate to be blessed with His guidance.

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ABSTRACT

The main purpose of this final year project is to study the process flow micro hydro system. Micro hydro system is primarily a system that uses natural water flow to generate electrical power. There is a waste of energy due to the excess of electrical power generated and a smaller amount of energy consumption. A project was carried out to design and simulate an energy storage system for micro hydro system to reduce the amount of energy wasted. The micro hydro system's powerhouse is a place where electrical energy was created via a turbine. There is an electronic load controller unit that acts as a controller to manage the electrical power generated by the system. The electrical power will divert to the main load assisted by the electronic load controller. The excessive electrical power produced will be channelled to the dummy load. Nonetheless, the electrical power that was channelled to the dummy load will usually be wasted or burned once there is zero power consumption. Therefore, this project will design and manufacture additional circuits in electronic load controller unit that can channel excess power to the second dummy load (energy storage) to meet the generated electrical power rather than redirect to dummy load and will be wasted. The excess energy can be used to pull a load, charge a battery, and heat up water. The gravitational energy of the load can be used to regenerate electricity, the battery can be used in the future and the hot clean water can be used for other purposes.

ABSTRAK

Tujuan utama projek tahun akhir ini adalah untuk mengkaji proses sistem mikro hidro. Sistem mikro hidro adalah sistem yang menggunakan aliran air semula jadi untuk menjana kuasa elektrik. Terdapat pembaziran tenaga berlaku kerana penghasilan kuasa elektrik yang lebihan dan penggunaan tenaga yang lebih kecil. Sebuah projek telah dijalankan untuk merekabentuk dan mensimulasikan sistem penyimpanan tenaga untuk sistem mikro hidro bagi mengurangkan jumlah sisa tenaga yang terbuang. Rumah kuasa system mikro hidro adalah tempat di mana tenaga elektrik dihasilkan melalui turbin. Terdapat unit pengawal beban elektronik yang berfungsi untuk mengawal dan menguruskan kuasa elektrik yang dihasilkan oleh sistem. Kuasa elektrik akan dialihkan ke beban utama yang dibantu oleh pengawal beban elektronik. Kuasa elektrik yang berlebihan yang dihasilkan akan disalurkan kepada beban dummy. Walau bagaimanapun, kuasa elektrik yang disalurkan kepada beban dummy biasanya akan sia-sia atau dibakar sebaik sahaja tiada penggunaan kuasa. Oleh itu, projek ini akan merekabentuk dan mengeluarkan litar tambahan untuk unit pengawal beban elektronik yang boleh menyalurkan lebihan kuasa kepada beban dummy kedua (simpanan tenaga) untuk memenuhi kuasa elektrik yang dihasilkan dan bukannya mengalihkan kepada beban dummy dan akan dibazirkan. Tenaga yang berlebihan boleh digunakan untuk menarik beban, mengecaskan bateri, dan memanaskan air. Tenaga graviti beban boleh digunakan untuk menjana semula tenaga elektrik, bateri boleh digunakan pada masa akan datang dan air bersih yang panas dapat digunakan untuk tujuan lain.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter will explain more about the background of the project, the problem statement and the objective of this project. Finally, it will also illustrate the scope of work to accomplish this project.

1.2 Project Background

Malaysia especially the rural area was ironic with streams and rivers flowing from highland areas, thus promise it with a lot of micro hydro power potential [1]. High pressure of water flow in the rivers generates a renewable energy that is electrical power by using the Micro Hydropower system. Micro Hydropower requires the high pressure of the water flowing from the river to create a force to rotate the blade of the turbine and generate an electricity. The rotating blade principle is essentially to transform the flowing water energy into rotational energy, which is converted into electricity [2]. The amount of energy created depends on the speed of the turbine. The faster the rotation of turbine's blade, the higher electrical power produced.

Micro Hydropower is a clean and renewable energy source in chorus. It only uses high pressure of water flow to generate electricity and does not consuming the resources of water. Hence, Micro Hydropower is environmentally friendly as it only requires water to generate power and act to minimize the environmental impact compared to fossil-fuel power plants. Additionally, it is an effective and reliable energy source as it continuously supplies electrical energy from the hydro power station based on the water cycle. The electrical power generated can be used up to a mile from the production site [3].

Rural areas are the most highly affected in terms of access to electricity. Electricity is the main pillar which affect the daily routine, health and education. Influence by the nonexistence of access to electricity, coupled with increasing of electricity demand, building on a hydropower as a source of energy are highly recommended.

Micro Hydropower usually was build based on advantages in geographical position. The installation of the micro hydropower needs to consider based on the contour and the physical conditions of the area. The volume of water flow will clarify the type of hydropower or turbine used for the specific area. Micro Hydropower installations can be classified based on the amount or energy generated per day. Hydro power classification can be summarized in Table 1.0.

Table 1.0: Classification of Hydro power [3]

Type of Hydro	**Power produced per day**
Pico	< 5 kW
Micro	5 – 100 kW
Mini	100kW – 1 MW
Small	1 - 5 MW
Medium	15 - 100 MW
Large	>100 MW

Based on the Table 1.0, the most suitable Hydropower system installation for rural area was micro hydro as the area has small rivers and streams flowing. This condition will result the volume of water flow at the rural area is low to produce high pressure of water toward generate large amount of electrical power.

1.3 Problem Statement

Hilly topography with meandering rivers and heavy rainfall, Sarawak has the highest potential for hydropower generation. However, rural area in this “Land of the Hornbills” still have no access to electricity and some of fraction are still depending on power generator to generate electricity for their daily usage. Due to the shortage faced by the rural population, the responsible party has taken various steps to solve this problem. One of step to solve this problem is by introducing the practice of micro hydro system. With implementation of the micro hydro system in the area, the system has been operated 24 hours daily. By using flowing water from the stream, the water pressure had enough potential energy to turn on the turbine, which can drive electricity generator. However, the problem is when the consumption of energy in that area is not utilized the power generated by the system.

Frequently the power consumption is low during the non-peak hour. Demand of electricity usually off-peak from 11pm to 8am. During that time, the consumers does not really use electricity where all of them mostly were resting or sleeping. This case will result in the electronic load controller channelling the excess power to dummy load in the micro hydro system. Dummy load or ballast is generally a place where the excess of energy generated was absorb and being released. This condition clearly demonstrated that the excess of energy was wasted as it was not fully utilized by the consumers. By conducting this study, the excess energy that has been wasted can be minimalized.

The main phase that needs to be done in solving the problem of wasted energy is build a controlling unit. The controlling circuit is designed to transfer excess energy to alternative energy storage. Alternative energy storage will store the excess energy into many difference kinds of energy storage that can be used for other operations. The energy storages can be used for the following systems:

- Motoring
- Battery charger
- Water heater

1.4 Objectives

The objectives of this final year project are;

1. To study the micro hydro working principle.
2. To design and build the alternative energy storage system for;
    a. Motoring
    b. Battery charger
    c. Heater
3. To use Arduino to control the process flow of the alternative energy storage system

1.5 Scope of Work

To accomplish the objectives above, some researches need to be done on the hydropower system. Preliminary search for the information about the working principle of the hydropower is significant to ease the construction of the thesis. Collection of data and statistic are very important as the evidence of the study. Also, this project needs to study on how the electronic load controller functioning on the hydropower system, as it is the important part in this hydropower system to divert excess power to dummy loads when the consumer load decreases. This project also requires designing and building the alternative energy storage system. The alternative energy storage system can transfer the excess energy to heater, battery charger and motor as act to minimize the wastage of energy produced. Lastly, Arduino Uno board was used to fabricate the working model for the alternative energy storage. Arduino Uno board acts to control excessive energy paths to be stored in a dummy load.

1.6 Report Outlines

In this chapter, research has been done to study the general knowledge of the micro hydro system. The operation of the micro hydro system was very important to acknowledge as it can help in the implementation of this project. In addition, the problems encountered by the Kampung Assum micro hydro system have been identified. The solution to the problems was also approved for execution.

In the nutshell, second alternative energy storage is vital for decrease the wastage of excessive electricity produces by micro hydro power plant. The excessive power needs to store for the use of any other works that need source of electricity. With the excessive energy, many works can be done to ease the burden of the villager. The villagers also can use the excessive energy for the daily routine work or for their mutual benefit.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will show the researches that has been done during this implementation of this project. The information and ideas obtained from the other resources will be stated in this chapter.

2.2 Micro Hydropower System

A site visit to Kampung Assum, Padawan has been conducted by a crew from Unimas namely the Centre of Renewable Energy (CREN) on the 18 December 2011 [4]. The main purpose of the site visit was to identify the village's potential for building a hydropower system. Due to the appropriate topography, the crew agreed to propose implementing the village's micro-hydro system. A 10kW + 5kW micro hydro system was proposed based on the estimated amount of power used for the long house of the villager. The energy needs to be produced to accommodate 50 houses and the mathematically allocated 300W for each house. Table 2.0 shows the specifications of the proposed micro hydro system for Kampung Assum.

Table 2.0: Proposed micro hydro system [4].

No.	**Item**	**Details**
1	Head	43 m
2	Flow rate	20 – 30 litre/s
3	Pipeline/penstock length	350 m
4	Transmission line length	1.5 km
5	Turbine type	Cross Flow

In implementation of micro hydro system, one of the important elements to take precedence is the head of the system. Head is defined as the vertical distance or height calculated from forebay level to powerhouse level. The measurement for the head is usually in meter and it is where the process of water flowing through the penstock. The height of the head is very vital to determine the amount of power produced by the system. The higher the height of the head, the higher the amount of energy produced. The high head of micro hydro system will result the high pressure of water flowing through the penstock that will move the blades of the turbine. One of the ways to maximize the height of the head is to locate the powerhouse at the lowest level below the forebay. This will ensure the highest amount of overall output power produced by the system. In the calculation of the head of the micro hydro system, both gross and net head need to consider. Gross head is the measurement of the vertical length between the top level of the penstock that delivers water under pressure and the low level of the powerhouse where is the water has been discharged. Net head can be determined by subtraction operation where the gross head deducts the pressure losses due to the friction existing in the piping [5]. Secondly, flow also a fundamental in measuring the power of electricity generated by the turbine. Flow is the volume of water that taken from the river or dam and sent through the turbine. Flow often measured in cubic metres per second but in small scale schemes, it is often measured in litres per second (where 1000 litres/second equals 1 cubic metre/second) [6]. Figure 2.0 shows the measurement for the head of micro hydro system.

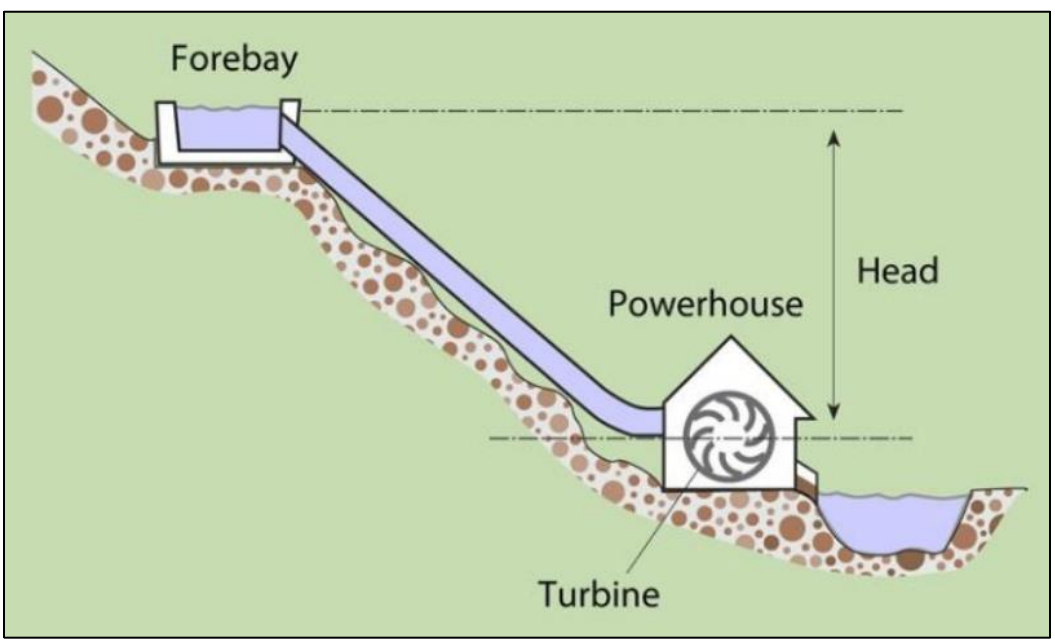

Figure 2.0: The elevation of micro hydro system [5]

2.2.1 Civil Components in Micro Hydro System

Micro hydro system is the simplest system that uses natural water flow to generate electricity. By converting the potential energy of the flowing water into electricity, generally up to 100kW of electricity generated by the micro-hydro system [7]. To ensure the successful micro hydro system as shown in Figure 2.1, there are major components need to set up together such as weir intake, forebay, penstock, powerhouse and transmission line.

- Weir intake

  This weir act as a small dam to store enough volume of water to run a micro hydro system especially during dry season. The weir has the spillway to eliminate the extra excess of water in the storage during heavy rain. This is the primary start for the water before it enters the forebay.

- Forebay

  Forebay is more alike an artificial pool that store the filtered and clean water. A filter is specially designed on the forebay to control the incoming water from weir into the forebay. The filter was built to prevent unwanted wreckages such as dry leaves and woods, or animals such as small fishes and turtles to enter the penstock.

- Penstock

  Penstock is a pipeline that transports water inside the powerhouse from the forebay tank to the turbine. The most commonly materials used for the penstock pipe the HDPE (High Density Polythene) pipe because of its durability and long-life expectancy [8].

- Powerhouse

  Powerhouse is a place where all the basic components to generate electricity located. The powerhouse is basically the stage where the water's potential energy is converted into electrical energy. The conversion of energy inside the powerhouse was assisted by the electro-mechanical equipment such as alternator, turbine, electronic load controller unit and dummy load or ballast.

- Transmission line

  Transmission line is the medium for supplying consumers with the electrical energy produced by the micro hydro system. The electric transmission system was structured using overhead cables and poles to distribute electricity along the village area.

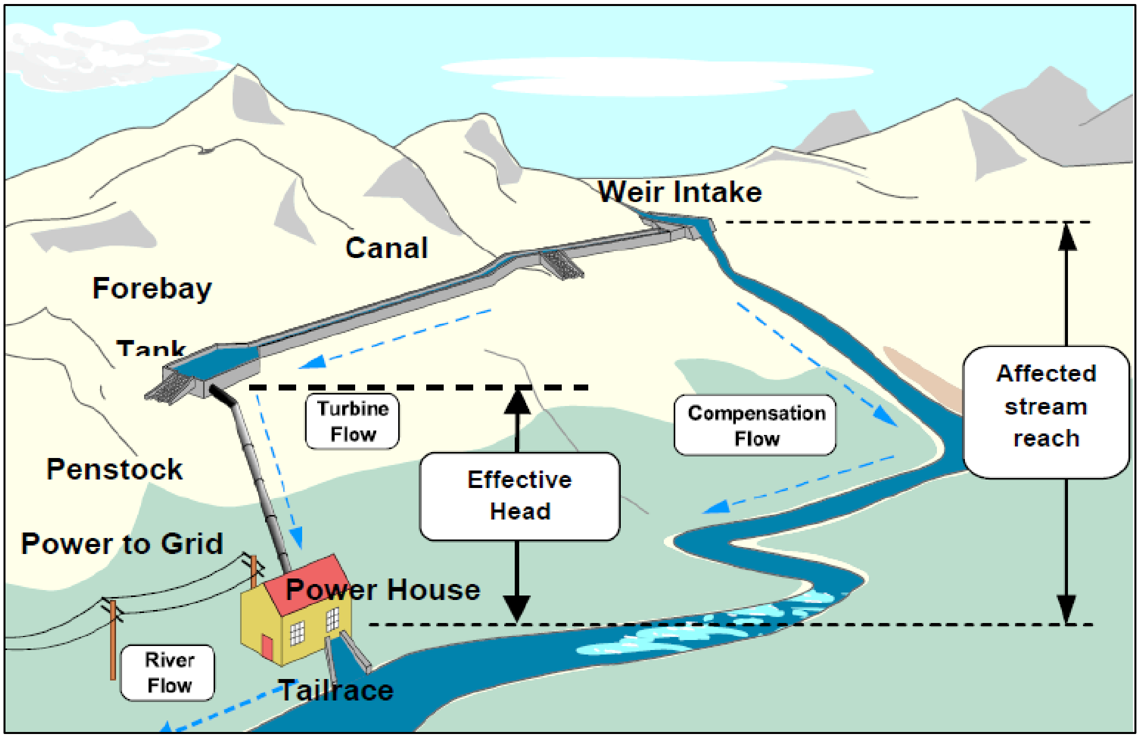

Figure 2.1: Micro hydro system's main component [9].

Generally, there are two (2) types of micro hydro configurations can be identified namely [10]:

- Run off river scheme

  This type of classification allows electricity generation without building storage or dam for water. It does not store water and uses water as it comes as there is no control on the flow of the water. The water from stream or rivers will be diverted through the forebay tank and then run through the penstock to drive the hydraulic turbine. If the minimum flow in the stream or river is sufficient to meet the peak power requirements of the load, it is often capable of supplying a rural area or industry with electrical needs. Run off rivers is environmentally friendly and low expenditure compared to other storage schemes. However, during the flow becomes too low or too high, for utility capacity and it requires a shutdown up until the flow returns to a suitable range. Figure 2.2 shows the diagram for run off river scheme.

Figure 2.2: Run off river scheme [10].

- Water storage (reservoir) scheme

  For this type of classification, reservoir is needed to store water in order to provide power on demand, whether to give highest power or to meet changeable loads. The creation of new lakes or construction of dam were necessitating to provide a place to keep the water. In contrast to the runoff river, this will affect the local environment in a positive and negative way. The cost of expenditure also might be high to build a new dam. This water storage scheme projects are interesting to provide the "saved" power during high electrical demand. New dam for storage reservoirs for micro-hydropower plants is generally financially viable in rural areas where energy values may be very high. Figure 2.3 shows the diagram for the water storage scheme.

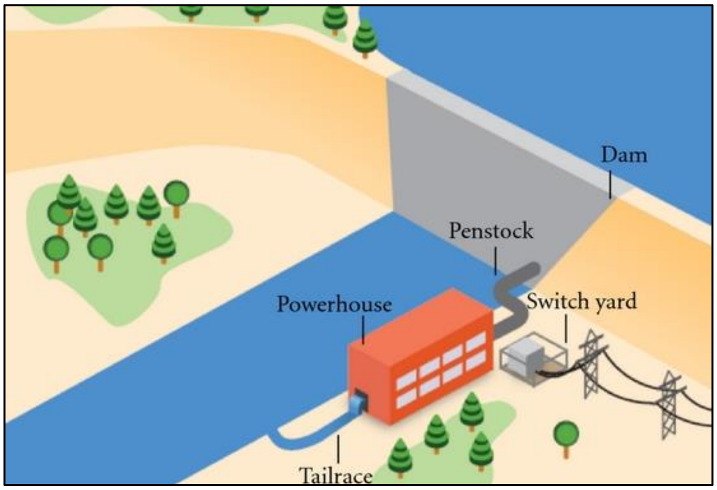

Figure 2.3: Illustration of water storage (reservoir) scheme [11]